

RAINFALL RELIABILITY IN AUSTRALIA.

By J. ANDREWS, B.A., Demonstrator in Geography, Sydney University.

(Three Text-figures.)

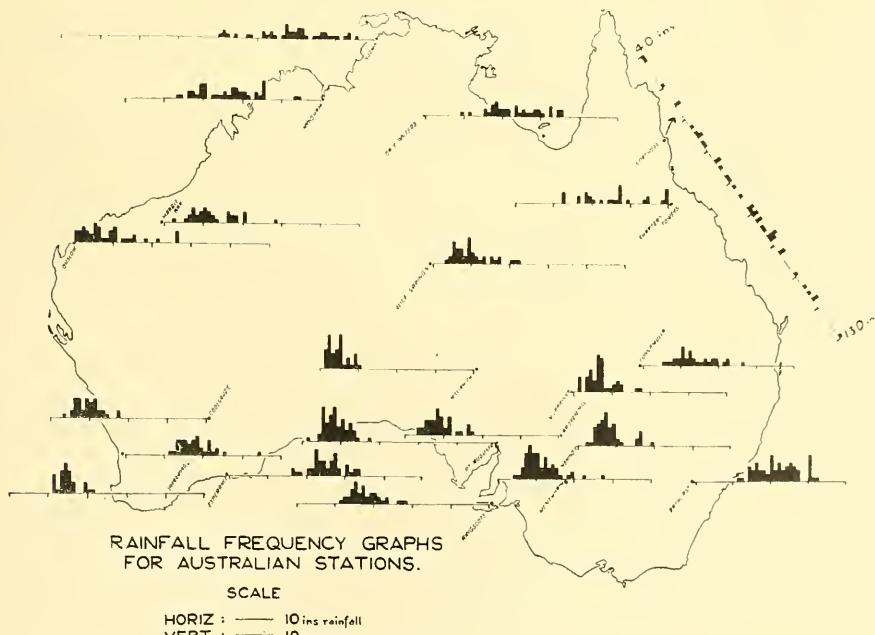
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Introduction.

From the point of view of the agriculturalist and pastoralist the most important aspect of rainfall generalization is the question of reliability. Rainfall reliability is principally concerned with (1) the amount of rain which might be expected during any season, and (2) the degree of probability of obtaining it. These two aspects are discussed here on the basis of annual figures and for the continent of Australia as a whole. It is hoped that later discussion of these aspects for regional areas and for seasonal periods will be presented.

Map of Most Frequent Rainfall.

Two values suggest themselves as expressions of rainfall expectation. It has been usual among geographers (and others) to use the arithmetical mean of



Map 1.—Frequency graphs of rainfall for the years of record at representative Australian stations. The number of years recorded varies from State to State, so that the general shape of the polygons is comparable, but the amplitude is not.

the observations and speak of the average annual rainfall. It is now, however, being realized that this average figure, calculated as it is over 35 years or more, may mean little in reality. It is expected that a glance at Map 1 will show how the average figure may give a quite wrong impression of the facts. Sometimes the average is a value that is never experienced; it is almost invariably higher than the value that occurs most frequently, and so to that extent it is misleading as a description of actual conditions. One further objection might be made to the exclusive use of this figure. From the point of view of the farmer, when once the rainfall for the period in question has dropped below the amount necessary for the growth of his crops, it is relatively unimportant whether the final total is 5 or 15 inches below the required amount. Similarly, an excess of rain over the required amount may produce harmful results (flooding, rust, etc.); yet these variations from his expectations affect the average value to a considerable degree, and may lead to false estimations of the possibilities of the region concerned.

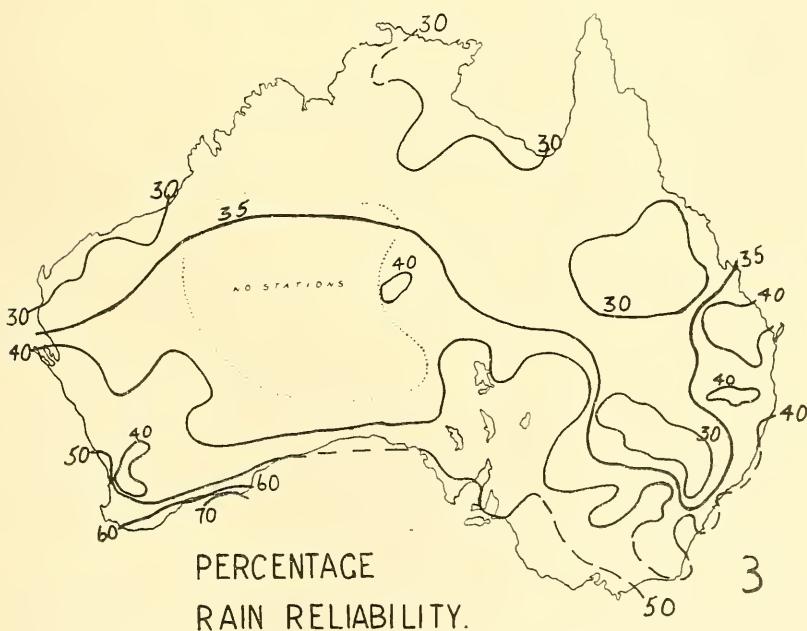
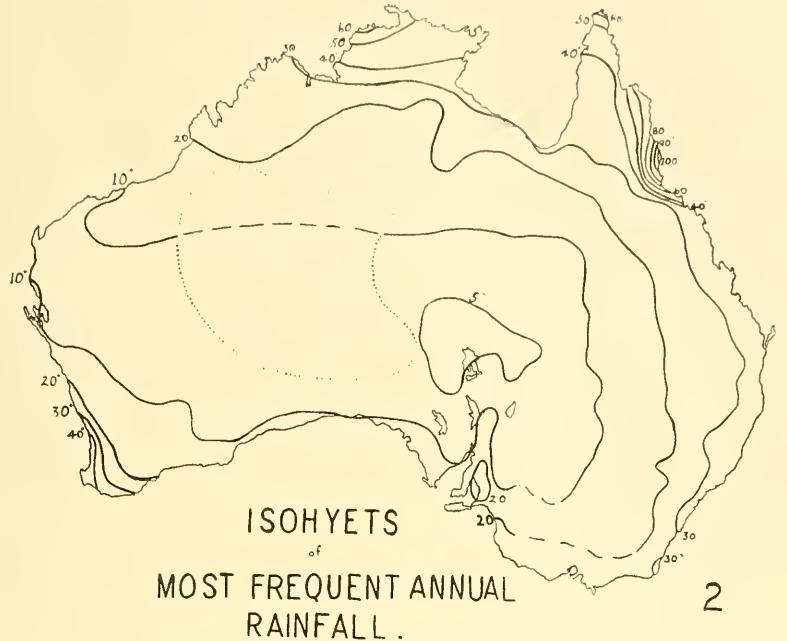
The mode (or value which occurs most frequently) offers another basis of determination. The modal frequency of the annual rainfall was determined for a large number of stations in each of the States, and Map 2 was constructed from these values. These figures have been obtained from observations spread over a long period, but, except in the case of New South Wales, the observations, while dating back to the commencement of observations, have not been taken up to the most recent years, but only so far as given in the Bulletins of Rainfall Observations for the various States. It is maintained, however, that the length of the periods dealt with is sufficient to give accurate cross-sections of the conditions prevailing at each station. In practically every case the period of observation is more than 20 years, and in very many cases more than 35 years. It is not likely that an additional few years' records would change the distribution of the frequencies to any notable extent.

Map 2, then, shows the isohyets of the most frequent annual rainfall calculated on the basis described. The points most deserving of attention in this map are: (i) The isohyets are concentric with the continental outline; (ii) there is a decrease in rainfall with increasing distance from the coast; (iii) in comparison with the average annual rainfall map (H. A. Hunt), the area receiving 20 in. or more is considerably reduced; (iv) the eastern half of Australia is favourably placed as compared with the western half, probably a result of the combination of the factor of elevation and the paths of the rain-bearing storms.

Rain Reliability.

The second step in our argument is to determine the method by which to obtain an index of the reliability of this most frequent rainfall value (referred to hereafter for the sake of convenience as the M.F.).

In this connection Griffith Taylor's (1920) map of "rainfall reliability" is important, for it is the map (and the method) most in use among geographers. It is held, however, that: (i) The values from which the map is constructed are obtained by expressing the mean departure from the average annual rainfall as a percentage of the average annual rainfall, a method that seems to the writer too loose and generalized for detailed use. Neither of the primary figures (mean departure and average annual) may be at all real in the sense that they ever occur at the station concerned. (See Holmes, 1931, where many of the stations show that the annual average rainfall was never experienced during the years



Map 2.—The isohyets of most frequent annual rainfall of Australia.
 Map 3.—The reliability of rainfall in Australia. The higher the index number, the greater is the reliability. Note the complexity of conditions in the south-eastern and south-western areas.

under observation.) (ii) A few large variations above the average may hide the fact (most important to the farmer) that the usual variation is a small amount below the average or vice versa. (iii) Once again, as in the case of the average annual rainfall map itself, the abnormal value has too great an influence on the final figure. Thus in the case of Onslow, as quoted by Griffith Taylor (1920, p. 157), the average variation is 50% on an average of 8 in. (*cf.*, however, *op. cit.*, p. 120, where the position of Onslow is shown outside the 10 in. isohyet). This, on Taylor's interpretation (1930) means that the most likely rains are from 4 in. to 12 in. Actually, however, from the records of the Rainfall Observations for W.A. (1928), only 9 years out of 43 had a rainfall of from 8 to 12 inches inclusive, while more than half of the years (24 out of 43) had a total rainfall below 8 inches. (iv) Obviously, then, the method of working with averages gives only a fictitious value when applied to all the stations. One effect is to give the station that has a small rainfall, but occasional years in which the fall is up to ten times the average, an appearance of unreliability; while stations of high rainfall might have departures as great which would be smaller in relation to the average value. Yet, as has been emphasized, both variations (20 in. on an average of 2 in. and 20 in. on an average of 60 in.) might be equally embarrassing to the farmer.

The method employed in making Map 3 is as follows: The number of years in which is received the M.F. rainfall is expressed as a percentage of the total numbers of years on record. That is: $R = \frac{100f}{y}$,

where R = degree of reliability, f = frequency of modal value, y = number of years on record.

The following points are to be considered:

(i) *Limiting percentages*.—From the point of view of the farmer there are certain fairly well defined limits of precipitation within which he can grow his crop, and outside of which he will not be able to farm on the same crop basis. These limits vary considerably for every crop and also for various farms under the same crop; but on the knowledge one has of the crop conditions in Australia, 10% has been selected as the limiting percentage. Therefore, in the formula the "f" value signifies the frequency of the modal value $\pm 10\%$. The value of the particular limiting percentage will not affect the value of the method; further work is being done on the determination of more precise figures for certain definite areas.

(ii) The final figure gives an index of the probability of occurrence of the M.F. rainfall. Thus a value of 50% for a station with an M.F. of 20 inches means that in five years out of ten that station will receive 20 in. $\pm 10\%$; or, in other words, the chances every year of receiving this amount are even. It is not, of course, regular alternation, but when such a high value is obtained, and since neither the good nor the bad years are found in groups, the years in which the value occurs cannot be very unevenly spaced.

(iii) In certain of the polygons (Map 1) there is apparent a well marked group of frequencies about the mode, but the modal frequency with the limiting percentage may not give the greatest possible number of observations. In such cases, therefore, the figure used has been the greatest possible number of years within the prescribed limits. The central figure of this range has usually been very close to the mode.

(iv) In one or two cases there were "double maxima", or two modes. Where later figures were not available to turn the balance between these, the modal frequency relating to the lower rainfall has been used.

Conclusions.

1. There is considerable uniformity in reliability over the continent, the greater part of which shows values between 30 and 50 per cent.
2. The concentric grouping of the isolines about the interior as shown in Map 2 has given place to a south-north increasing unreliability, with certain modifying factors operating along the eastern coasts and highlands.
3. The most reliable region is some distance east of Cape Leeuwin with very high figures.
4. The points of greatest resemblance between this map and Taylor's are this south-western region, and that of the north-western coast from Onslow to Broome, which is one of the regions of least reliable rainfall in Australia. In the interior and in the east the differences between the two maps are striking.
5. One of the most interesting features is the great Flinders-Torrens loop. Here a region of high reliability stretches from Milparinka (47) and Broken Hill (39) west to the centre of South Australia. This great loop is almost certainly due to the great bays in the coast and to the Torrens rift valley, in so far as they affect the paths of rain-bearing winds. East into New South Wales the reliability declines, and the central plain of the State has low reliability (Bourke, 21). This belt extends to the highlands (Bathurst, 29); thence there is an increase in reliability to the coast (Sydney, 37).
6. Along the eastern highlands there are some interesting and rather puzzling features. The broken areas and the relative positions of the isolines indicate that in some cases the influences at work over the plain (Central New South Wales and Central Queensland) sometimes extend to the highlands, while other parts of the highlands area are higher or are so placed with reference to the storm tracks that they benefit uniformly. Detailed work remains to be done on these regions. It is interesting to note, however, that as regards New South Wales the areas of greatest reliability are the Far West, a strip of the Southern Slopes, and the Coastal strip.
7. As Taylor notes, there is an unreliable region about the Gulf of Carpentaria, although it is defined differently in the two maps. It is noteworthy that on the North Queensland coast there are one or two stations with values below 30. A fair proportion of the rain of the two regions comes from hurricanes, and as these move along fairly well frequented tracks, the regions may not be as uniform as indicated.
8. The interior has quite a considerable degree of reliability; it is notably greater than that of the eastern plains mentioned above. The region of Alice Springs, probably on account of the presence of mountain ranges, has an even greater reliability than most of the interior. It should be noted, of course, that there is a large area in Western Australia with no recorded observations.

These results are in conflict with the generally held opinions regarding the rains of the interior, and it is worth while to examine some of the factors that have given rise to these opinions: (i) In the first place, the farmer or the pastoralist usually judges his rainfall characters by the response of the vegetation, although this is by no means a complete reflection of rainfall. There is, for instance, a

definite lag in response in areas that have suffered several bad years in succession, even when conditions are not complicated by stocking. (ii) In the case of the farmer on the dry side of the wheat belt, there is small margin on the low side of rainfall, so that each variation below his expectation impresses itself on his notice, while in wetter regions the same percentage variation may not have any untoward effect. In other words, the farmer of the outer belt is depending on the higher values, while the more fortunate farmer inland relies on the low values. Hence arises the conception that the rainfall of one area is less reliable than that of another, though actually there is little to choose between them. (iii) The same argument applies to grasses in the arid belts. (iv) It must not be forgotten that we are dealing here with annual summations, and that the most important factors for plant growth are the amount of individual fall and the time period between falls. In this particular map these factors are necessarily ignored. (v) It seems to be indicated that the problem of settling much of the interior is the problem of finding crops (fodder or otherwise) that will grow with from four to eight inches per year.

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